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CONTENTS

The American Association for the Advancement of Science:—
Recent Progress in Spectroscopy: PROFESSOR E. P. LEWIS 899

William Rane Lazenby: PROFESSOR J. H. COMSTOCK 912

Scientific Events:—
Anthropological Essays in Honor of Professor W. H. Holmes; Dedication of a Tablet in Honor of Professor Volney M. Spalding; Smithsonian Regents Meeting..... 913

Scientific Notes and News 916

University and Educational News 918

Discussion and Correspondence:—
A Reply to "Methods of Criticism of 'Soil Bacteria and Phosphates'": H. J. WHEELER.
1916 or 1816: DR. ALEŠ HRDLIČKA 919

Quotations:—
Science in Germany from an English Viewpoint 921

Scientific Books:—
Soils, their Properties and Management; Chamberlain's Organic Agricultural Chemistry: PROFESSOR C. W. STODDART 922

The United States Geological Survey Maps... 923

A New Insect Enemy of the Peach 925

Special Articles:—
The Habit of Leaf-oviposition among the Parasitic Hymenoptera: HARRY SCOTT SMITH 925

Societies and Academies:—
New Orleans Academy of Sciences: R. S. COCKS. *The Botanical Society of Washington:* H. L. SHANTZ 926

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

RECENT PROGRESS IN SPECTROSCOPY[1]

WE should pause a moment to pay a tribute of respect to the eminent physicists who have died during the past year. Among these may be named John Oren Reed, of the University of Michigan; Arthur W. Wright, one of the pioneers in physical research in this country; Cleveland Abbe, the father of the Weather Bureau; Sylvanus Thompson, the many-sided scholar; Ernst Mach, the philosophic thinker, and Pierre Duhem, the mathematical physicist. We honor these men for their achievements, but we need not grieve that they have left us, for their full day's work was done; but sorrow we must over the needless and untimely end of many young men who had given promise of brilliant careers, and countless others, whose names we shall never know, whose potential genius has been sacrificed to the Moloch which is the mongrel offspring of the union of a brutish feudalism with the vampire of commercial exploitation. While we may form some conception of the loss of life and property in the great war, no one can ever guess the extent of the irreparable loss to humanity caused by the destruction of embryo scholars and statesmen, artists and scientists. It is the irony of fate that so many scientists have been the victims of the conditions arising from ignorance, superstition, greed and devotion to outworn traditions

[1] Address of the vice-president and chairman of Section B—Physics—of the American Association for the Advancement of Science, New York meeting, December, 1916.

which science has ever sought to remedy; and yet there are many who hold science in some measure responsible for the terrible destructiveness of this war. Fire is man's friend, but it may become a terrible scourge when uncontrolled; and so the beneficent discoveries of science may be perverted to evil ends. We must remember, however, that death-dealing devices based on scientific discoveries may be the defense of the rights and liberties of peoples as well as the instruments of those who would devastate the world for their own advantage. There have always been those who have exploited the discoveries of science for their own selfish ends, but who can point to one of these exploiters who was himself a scientist? When we are told that the ends of science are material, let us think of Faraday, who never had time for money-making; when we are told that the aims of science are selfish, let us think of the men engaged in medical research who have sacrificed themselves to discover how others might be saved. Such men are typical of the ideals of science. Yet it is true that we are sometimes too much absorbed in our individual work, although our aims may be unselfish. With the lesson before us of the great cataclysm in Europe, we must not only recognize our greater responsibility in carrying forward scientific investigation, but we must likewise seek to arouse in our people a fuller realization of the relations of this work to their own happiness and prosperity. Conditions and habits of thought similar to those which have brought disaster upon Europe are not entirely absent from our own country, and will have similar results if not remedied in time. Certain social, economic and political ills which are held to be inevitable to imperfect humanity by minds which move in the grooves of tradition or of legalistic logic may be found capable of improvement if treated by scientific methods, which seek the truth regardless of the harm it may do to ancient superstitions, prejudices and privileges. We must look to those who think scientifically, even though they may not call themselves scientists, to replace our haphazard ways in agriculture, business, manufacture, law and politics, our criminal wastefulness and careless extravagance, by more efficient methods, not only to the end of increasing national prosperity, but still more to the end of promoting intellectual development, universal justice and happiness, unselfish and enlightened patriotism, and exalted ideals of life and conduct. Fortunately there seems to be a growing tendency to recognize the service which science may render to society. For the first time in our history, our government has sought advice from scientific men, and those who have been called upon are giving their services fully and loyally, with no thought of pay or political preferment.

It seems not altogether irrelevant to preface my remarks with this protest against some current criticism of science; but now I turn to the specific subject of my address.

Ten years ago the subject of Professor Crew's vice-presidential address was "Facts and Theories in Spectroscopy." Since that time some notable discoveries have been made and some remarkable theories have challenged attention. It is my purpose to review a few of the more important experimental results and to discuss the relations of some of them to theories brought before you in two recent vice-presidential addresses on "Atomic Theories of Radiation" and "The Theory of the Nucleus Atom." Inasmuch as it will be necessary to refer to them, I will restate the salient features of the theories which have attracted the most attention.

Planck derived an expression for the

spectral energy distribution of black-body radiation from the assumption that the radiation was emitted and absorbed by electric oscillators in definite quanta, each equal to the frequency of the oscillator multiplied by a universal constant, h, the wirkungsquantum. Later he modified this theory so far as absorption is concerned. Einstein and others went further in assuming that these quanta preserve their identity in their propagation through space, thus reviving a form of corpuscular theory. This extreme view has been generally abandoned, but it has been found impossible to explain away the wirkungsquantum h. It appears in too many relations to be the result of chance. The work of Millikan in particular proves the exact validity of Einstein's relation $Ve = h(\nu - \nu_0)$ in the photoelectric effect, in which Ve is the measure of the emission energy of the electrons, ν the frequency of the incident light, and ν_0 the minimum frequency which will cause emission of electrons. A similar relation appears to hold good in many cases of X-ray and light spectra. It seems probable that this constant depends upon atomic structure only, and affects radiation through space only in so far as emission and absorption are determined by atomic structure.

The theory of the nucleus atom is likewise of fundamental importance in spectroscopy. The work of Rutherford and others leaves no escape from the conclusion that the nucleus of the atom is a concentrated group of positive charges and electrons, with an excess of positive elementary charges approximately equal to half the atomic weight, while the same number of electrons circulate about the nucleus in rings. The spectroscopist must try to fit his theories to these probable facts, but he is met at the outset with apparently insuperable difficulties in accounting for the stability of such atoms and for the manifold complexity of spectra according to accepted electrodynamical laws. Bohr cut the Gordian knot by supposing that the classic laws apply only to conditions of stability, when no energy is radiated, and that radiation attends the transition of an electron from one state of stability to another, the frequency being determined by the relation that h multiplied by the frequency is equal to the difference between the energies of the system in the two stable states. In the case of hydrogen, to which he assigns one radiating electron and one nucleus charge, it is difficult to account for the existence of so many stable states, for the failure to radiate while subject to uniform radial acceleration, and for monochromatic radiation while passing between two positions of stability. Nevertheless Bohr derived an expression like that of Rydberg which locates accurately not only the Balmer series, but also an infrared and an ultra-violet series predicted by Ritz and found by Paschen and by Lyman, respectively. His attempt to apply the same method to helium led to results which are still in dispute, and which will be referred to later.

In reviewing recent progress we may begin with that field in which this country has taken a leading part—that of astrophysics. This domain belongs as much to the physicist as to the astronomer. The heavenly bodies are laboratories on a vast scale, in which nature has provided conditions of temperature, pressure and electrical state which we may never hope to rival on the earth. The spectroscope gives us data from which it may be possible to form some idea of these conditions by comparison with our feeble laboratory imitations of celestial phenomena, and conversely, the latter may aid in the interpretation of terrestrial phenomena.

One of the most fruitful astronomical applications of the spectroscope is to the

determination of velocities in the line of sight, by the Doppler-Fizeau principle. A large mass of such data has been collected, from which some important generalizations have been derived. For example, Campbell has determined the velocity and direction of motion of the solar system through space, and has found a remarkable and as yet unexplained relation between the velocities of stars and their apparent age, the redder and presumably older stars and a class of nebulæ having in general the greater velocities. It likewise appears that two immense star streams are crossing each other in the Milky Way. Many spectroscopic binaries have been discovered and their orbits determined, and recently there have been found remarkable displacements and rotations in nebulæ which may throw some light on the nature and destiny of these bodies. The spectroscope has enabled astronomers to undertake the ambitious task of tracing the course of stellar evolution.

The most ingenious and fruitful device for studying the sun is the spectroheliograph, invented by Hale in 1892. With this instrument photographs of the distribution of a given constituent of the solar atmosphere may be obtained by restricting the light falling on the photographic plate to the wave-length of one of the characteristic lines of the element. The configuration of the hydrogen clouds in the neighborhood of sunspots led Hale to suspect vortical motions in such regions. In 1908 the study of a number of plates, which showed that hydrogen flocculi were actually drawn into these spots from great distances, proved without question that sunspots are cyclonic areas of enormous extent. Thus the long-disputed question as to the nature of sunspots was answered, but this was not all. Vapors which emit or absorb line spectra are ionized, and as the more mobile electrons would diffuse more rapidly to higher levels than the positive ions, Hale inferred that the immense whirls of electrified vapors in the neighborhood of the spots must cause a radial magnetic field. If such fields are sufficiently intense, the longitudinal Zeeman effect should be produced. As a matter of fact, the spectrum of light from the spots is characteristically different from that of the surrounding photosphere, one of these peculiarities being the doubling of many lines. As Hale anticipated, an examination of the state of polarization of such lines showed them to be circularly polarized, and the direction indicated that the whirling vapor was negatively electrified. Hale likewise sought for the more minute effects which might be expected from the rotation of the solar atmosphere as a whole. A study of the breadth of spectral lines at different latitudes and the detection of traces of circular polarization at their edges showed that the sun possesses a magnetic field with polarity corresponding to that of the earth, but of much greater intensity. Although the atmospheric conditions on the earth are very different from those on the sun, it is possible that these investigations may assist us in solving the baffling problem of the earth's magnetism.

One of the most impressive facts revealed by the spectroscope is the substantial identity of constitution of the heavenly bodies. Everywhere we find evidence of the existence of such elements as hydrogen, sodium, calcium and iron. But we also find an infinitude of differences in the appearance of the lines, which we must attribute to differences of temperature, vapor density, pressure and electrical condition. It is suggestive to find that the spectrum of some stars resembles that of the arc, of others that of the spark. We may hope by comparing the spectra of these bodies with those produced in our

laboratories under varied conditions to reach some conclusions regarding their physical state. The Mount Wilson physical laboratory is doing much valuable work of this kind.

In the spectra of the solar corona and of nebulæ and nebulous stars certain lines are found which do not belong to known elements. This need not indicate any fundamental differences between the life history of such bodies and that of the older stars. Twenty-five years ago Lockyer's views regarding the dissociation of elements in the stars were treated with levity by most physicists and astronomers. Today such notions are held to be quite rational. The more elementary forms of matter would naturally be of small atomic weight, and hence would diffuse to higher levels than the heavier elements, and might ultimately escape into space. If it were not for the fact that it is held captive in chemical combinations, we should know nothing of hydrogen. Helium first revealed itself to us through its solar lines, and would still be otherwise unknown to us were it not for its continuous production in radioactive processes. The elements giving the spectra of the corona and of the nebulæ are presumably of small atomic weight, and are possibly the units out of which more complex known elements are built, in later stages of development; or they may be, conversely, the results of the disintegration of such elements. It is not impossible that in the future we may detect traces of these elements on the earth or manufacture them by some powerful disintegrative process. Meanwhile deductions from known relations between frequencies of the spectral lines, their breadth, and the atomic weight of the elements may give us some clue to their atomic weights. Nicholson has succeeded in constructing hypothetical atoms with given nuclear charges and electron ring systems which give with remarkable accuracy the positions of the lines of the corona and nebulæ. Rayleigh showed from kinetic theory and Michelson proved experimentally that at low pressures the width of lines may be entirely due to Doppler displacements, which vary directly as the square root of the absolute temperature and inversely as the square root of the atomic weight. Buisson and Fabry have verified this law and applied it to the study of nebulæ. The width of certain lines, determined from the limit of interference, indicates that the temperature of the Orion nebula is about 15,000 degrees, and that two groups of lines are due to atoms of weights 2.72 and between 1 and 2 respectively. This is a remarkable confirmation of Nicholson's previous conclusion that the emission centers are of atomic weights 2.95 and 1.31.

During the past ten years the boundaries of the known spectrum have been greatly extended in both directions. The difficulties of investigation in the infrared are very great, but by the methods of reststrahlen and of focal isolation Rubens, working in succession with Nichols, Wood and von Baeyer, has isolated and measured certain regions of great wave-length. The longest wave-length measured is about .3 mm., while the shortest Hertzian waves so far obtained are 2 mm. long. The study of line radiation in this region is even more difficult, but Paschen and his pupil, the American Randall, have succeeded in measuring many lines extending to about 90,000 Ångström units.

In the ultra-violet Lyman has extended the region first made known to us by Schumann to a wave-length of about 600 Ångström units. Beyond this point it is difficult to go, on account of absorption, lack of sensitiveness of the photographic plate, and small reflecting power of speculum metal. Gratings ruled on silicon and photoelectric detectors may enable us to bridge the gap between these waves and

the much shorter ones which may be examined with the aid of nature's diffraction gratings, crystals, which have made the study of X-ray spectra possible.

Of all the discoveries of recent years, that of the wave nature of the X-rays and of a practical method of examining their spectra is the most remarkable and the most important, for it has revealed to us the most fundamental radiations of the elements and has given us a glimpse into the very heart of the atom. In quick succession Laue and his pupils demonstrated the diffraction effects produced by crystals, the Braggs showed how reflection might be employed to isolate waves of different lengths by a principle similar to that producing colors of thin plates, but of far greater resolving power by reason of the greater number of effective reflecting surfaces, and Moseley photographed many characteristic spectra by an extraordinarily simple method. He found that the principal lines in the spectra of a large number of elements were connected by a remarkably simple relation, namely that the square roots of the frequencies are proportional to the ordinal numbers, which increase by one in passing from one number of a periodic group to the next. When there are anomalies between the atomic weight and the place of an element in a group, this anomaly disappears when the atomic number rather than the atomic weight is considered. This work has been extended by others, notably by Siegbahn and Friman, to include nearly all the known elements between sodium and uranium, inclusive, with the result that all the atomic numbers between hydrogen and uranium are accounted for, with the exception of six gaps. As interpreted by Bohr's theory, the ordinal number which determines the frequency is the excess number of positive elementary charges in the nucleus, and these results are, therefore, in complete harmony with the theory of the nuclear atom developed by Rutherford, van den Broek, Soddy and others. The comparison of the X-ray spectrum of lead obtained by Siegbahn with the gamma-ray spectrum of radium B obtained by Rutherford and Andrade shows the identity of ten of the principal lines. This strikingly confirms the accepted theory of isotopes, or elements of different atomic weights, which are chemically and spectroscopically alike because they have the same resultant nuclear charge.

The positions of the principal lines are consistent with Bohr's general formula, but perhaps this relationship is purely formal. But whether or not this theory applies, apparently we can not dispense with the wirkungsquantum. In addition to the characteristic X-radiation of an element, there is a continuous spectrum, with a sharply defined boundary on the side of shorter wave-lengths. The investigations of Duane, Hull and D. L. Webster have shown that this boundary is accurately defined by Einstein's relation $Ve = h\nu$ for fields up to 110,000 volts. Such a simple law does not hold for the characteristic radiations; but Webster has shown that they do not appear until the voltage somewhat exceeds that demanded by the Einstein relation. The longest X-waves so far discovered by Siegbahn are about 12 Ångström units in length, so that there is not a very great gap between them and the shortest waves discovered by Lyman. The investigation of this region is difficult, but undoubtedly means will be found to attain success. Much also remains to be done in the study of details of X-ray spectra, which contain many weak lines, and possibly bands, which have not so far been carefully examined.

During the past ten years great advance has been made in our knowledge of spectral series. Rydberg, Ritz, Paschen, Fow-

ler and others have shown that a generalized form of the Balmer equation, with Rydberg's universal constant and a few special constants, is capable of wide application. Different combinations of a few constants have been found to give a number of related series, and many new lines so predicted have been found. The common limit and other numerical relationships between different series of the same element indicates that the different emission centers have some dynamic coupling and Rydberg's universal constant indicates a structural element common to all substances. According to Bohr, this quantity is a function of the electronic and atomic mass, the elementary electrical charge, and the wirkungsquantum h, and should slightly increase with increasing atomic weight. As it is commonly assumed that it is an absolute constant, careful measurements may furnish a test of the validity of Bohr's theory.

The relationships of frequency to atomic number found by Moseley recalls that Ramage, Watts, Runge and Precht and Hicks have found linear relationships between the squares of the atomic weights and the frequencies or frequency differences of homologous lines in the spectra of elements of the same group. Ives and Stuhlmann have shown that in some cases the results are improved by substituting atomic numbers for atomic weights, but the relationship is evidently not so simple as in the case of X-ray spectra.

The discovery of the Zeeman effect and the explanation of its simpler forms by Lorentz was the first step toward a rational spectroscopic theory. The later discovered complexities and anomalies, while they may defy mathematical analysis, do not lessen our confidence in the theory, for they are what we might expect as a result of complicated atomic structure. The same intellectual satisfaction does not attend the discovery of the analogous effect of an electric field, because the simplest cases are so complex that they can not be adequately explained by any theory yet proposed. The possibility of such an effect had long been the subject of speculation, but Stark was the first to realize and attain the necessary conditions for its occurrence. Lo Surdo also discovered it in the neighborhood of the cathode in capillary tubes. As in the case of the Zeeman effect, the phenomena are different when viewed transversely and parallel to the field. In each case the lines are split into a number of components, the number being different for different lines, even for those belonging to the same series. In the transverse effect the components are plane-polarized in hydrogen and helium, the stronger central lines vibrating at right angles to the field, and the stronger outer components vibrating parallel to the field. A remarkable relation is found for the series lines of hydrogen, helium and lithium. For each the number of principal normal components appears to be equal to the ordinal number of the line in the series. Higher dispersion shows that in the case of hydrogen each component is double. If this rule holds good throughout the series, the last known line, the twenty-eighth, would have 56 such components, an equal number polarized at right angles to these, and a number of weaker components of both kinds—truly a formidably complicated system. In general the longitudinal components appear to be unpolarized, although Miss Howell has found some anomalies with lithium and calcium. In some cases the components are unsymmetrical both in position and in intensity. Of all the other elements investigated, mercury alone shows a slight broadening. It might be expected that the great nuclear charges of heavy atoms would diminish the effect of an external

field. The inverse absorption effect has so far not been observed.

Long before the Stark effect was observed Voigt showed that such results might be expected from quasi-elastic forces in the atom and the stresses produced by the field. Schwarzschild has attempted to explain it by the ordinary laws of electrodynamics, and Warburg, Gehrcke, Garbasso and Bohr by Bohr's theory. Each attempt was successful in some respects, but each failed to account fully for all the components, their displacements and their state of polarization, and all the theories assign the same number of components to each line of a series, whereas one of the most significant features is the progressive difference in number of components, displacements and relative intensities in passing from one line to another. Stark not only rejects them all, but is led by his study of the phenomenon to finally abandon the quantum and light-cell theories, because he considers that he has proved that the greatest possible energy which an electron can acquire in its orbit falls far short of one energy quantum. Moreover, he argues that it seems impossible to explain the phenomenon in terms of Bohr's one electron. He concludes that a number of electrons must take part in the emission of a single line, each having the same frequency under ordinary conditions or in a magnetic field, but different frequencies when displaced unsymmetrically in an electric field. It is difficult, however, to understand why hydrogen has only one detachable electron if Stark's view is correct.

It has already been mentioned that at low pressures the width of lines may be ascribed entirely to the Doppler effect. The great broadening at higher pressures has never been explained, but it has been assumed that damping, collisions and rotations all play a part. Stark suggests that it may be largely due to atomic electric fields, which may exercise a large influence when the atoms are crowded together. It seems significant that the broadening increases with the ordinal number of a line in a series, is often unsymmetrical, and diminishes with increasing atomic weight in most cases, quite in harmony with the effects of an electric field. Nicholson and Merton have found that the broadening of hydrogen lines is in quantitative agreement with Stark's suggestion.

With changes in vapor density, pressure, temperature or the mode of excitation lines belonging to one series may weaken or disappear, other lines may be strengthened, and new lines may appear. We must assume that different groups of lines are due to different emission centers. These differences must depend upon the size of the particles, or upon the number and arrangement of electrons. Any theory must take account of the molecular or atomic state or the electrical charge of the emission centers. In some cases we have rather definite information on these points.

A number of elements emit band spectra under some conditions, line spectra under others. One conclusion which seems to be well established is that band spectra are emitted by molecules, line spectra by atoms. Universally we find that compounds give band spectra, never line spectra. If a compound is dissociated by the discharge the line spectrum of one or both constituents appears. Elements give band spectra with feeble excitation, line spectra when the discharge is so intense as to cause dissociation. It seems reasonable to infer that the band spectra of elements is likewise associated with the molecular condition. In the case of monatomic elements which give both band and line spectra electrical conditions must determine the nature of the radiation.

Radiation is an electromagnetic process,

and must be determined by the electrical state of the radiator. A molecule may be neutral or for a moment charged by the loss or gain of an electron. This type of ionization must actually occur, as indicated by the conduction of electricity through the vapor of a compound which shows no evidence of chemical dissociation. What causes the light emission? It may accompany the loss or gain of an electron by a neutral molecule, in which case the emission center would be charged. It may be due to the shock of elastic collision with an electron or ion, or to the reunion of an electron with a positively charged molecule, in which cases the emission center would be neutral. Luminous vapors emitting band spectra usually appear to be neutral at the instant of emission, so that it seems probable that band emission is due either to elastic shock or to the recovery of a lost electron. It is to be remarked that as a rule band spectra are not subject to the Zeeman, Stark or Humphreys-Mohler effect; in the exceptional cases it is probable that those subject to one of these effects are subject to all. It would be of interest to examine these cases with reference to the nature of the molecular charge.

Luminous vapors emitting line spectra appear, in many cases at least, to be positively charged. A sodium flame is attracted to the negative plate of a condenser. A metallic salt introduced near the cathode of a spark discharge colors the spark only in that neighborhood; if introduced near the anode, the color flashes entirely across the spark. The most promising method of verifying such conclusions appears to be by the study of canal or positive rays. Sir Joseph Thomson, from a study of the deflections produced by magnetic and electric fields, found that, with very few exceptions, no molecules of either elements or compounds carry a negative charge, while those with positive charges are common. No molecule acquires more than one positive charge. The atoms of but few elements are found with a negative charge, but all may acquire positive charges and many may be multiply charged. For example, krypton may have as many as five and mercury eight positive charges. Hydrogen never has more than one charge, which accords with Bohr's view that it has but one detachable electron.

Stark has reached similar conclusions from a study of the spectra of canal rays. In many cases the motion in the line of sight gives a Doppler effect. There is an undisplaced line due to the stationary gas and a displaced line due to the canal rays. A distinct separation between the displaced and stationary lines shows that the canal rays can not radiate until their kinetic energy reaches a threshold value, which Stark first interpreted in favor of the quantum theory, but which he now believes to represent the energy necessary for ionization. There may be two or even three displaced lines, with separations consistent with the view that the luminous centers are doubly or triply charged. The radiation is evidently due to collisions, for a reduction of pressure in the canal ray chamber causes a reduction of luminosity. In general, all series lines are subject to the Doppler effect. Fulcher has shown that nitrogen canal rays give the negative pole band spectrum, with displacements, but no other bands have been found to give this effect. The series lines of hydrogen show displacements, but they are not observed in the many-line spectrum except to a slight extent in a few cases. Stark concludes that the series lines are emitted by positive atom ions, and the lines of the secondary spectrum by neutral atoms. He thus associates the compound spectrum with band spectra, which he supposes to be due to neutral systems. It may

be remarked that Fabry and Buisson have concluded from measurements of the width of lines that both spectra are due to emission centers of atomic size. From a study of the displaced components of many elements, electronegative as well as electropositive, Stark concluded that in all cases line spectra are emitted by positively charged atoms. Aluminum atom ions may have one, two or three charges, which appear in succession as the voltage is increased. The same is true of argon. The red spectrum is apparently due to singly charged ions, the blue or spark spectrum to multiple charges. Mercury may have as many as four charges, each giving rise to a characteristic group of lines, all those due to multiple charges being spark lines. From an examination of many such cases Stark concludes that in general arc lines or those of the positive column are due to singly charged ions, sharp spark lines to double charges, and diffuse spark lines to triple charges. There are some apparent exceptions to this classification, but in the main the evidence seems to support his views, which are also consistent with the results obtained by Reichenheim from the study of anode rays. For the first time we are thus enabled to assign a common cause for spark lines produced under apparently very different conditions. They are found in the spectra of disruptive discharges, of the negative glow in vacuum tubes; in the intermittent or oscillating arc when rapid changes in potential occur, although the maximum potential may be small; near the poles of the arc, where the anode and cathode potential gradients are steep; in the electric furnace when the temperature is high; in high temperature stars, and, as found by Hemsalech and de Watteville, even in the green cone of the Bunsen flame, where chemical action is energetic. In all these cases we might expect multiple ionization to be favored.

Similar conclusions regarding the charges of emission centers may be derived from observations by Stark, Child, Strutt and others on the luminous vapors from an arc between charged condenser plates. The carriers of the line spectra are swept out of the field, while the luminous vapors giving band spectra are unaffected; or, if the lines of several series are present, their intensities are modified in different degrees by the electric field. Studies of the oscillatory spark by Schuster and Hemsalech, Schenck, Milner, Royds and others indicate that the spark lines do not persist as long as arc lines. If the emission centers of the former are multiply charged this is what we might expect.

Investigations on the mechanism of the spark give results which at first sight seem opposed to Stark's theory. All observers agree that the luminous vapors appear to be projected from the cathode, with different velocities for different lines, and the tacit assumption seems to have been made that they are negatively charged. That metallic vapors are projected from the cathode is evident from the fact of cathode disintegration, and probably the particles are initially negatively charged. We know very little concerning this phenomenon, but two things are almost certain—that only a small fraction of the metallic particles take part in the luminosity, and that these particles are not negatively charged while radiating. The large velocities indicated by the curvature of the streamers viewed in a rotating mirror do not give rise to a corresponding Doppler effect, and it seems highly probable that Hull and Royds are correct in their surmise that what happens is really the propagation of a condition of luminosity through vapor which continuously fills the gap after the first discharge. Electrons initially projected with a high velocity, which diminishes as the field intensity

drops to zero, and producing multiply charged ions in the beginning and singly charged ions toward the end of their course, would apparently account for all the observed effects.

While the experimental evidence seems to favor the idea that lines are emitted by positively charged centers, there is no *a priori* reason why neutral or even negative ions should not emit line spectra. It is quite possible that the canal ray lines which Stark attributes to singly charged ions may be emitted at the instant of neutralization; but we can not escape the conclusion that spark lines at least are emitted by positive ions unless we accept the improbable view that a multiple charge may be instantaneously entirely neutralized. Lenard inferred from the distribution of emission centers in the arc that the lines of the principal series are emitted by neutral atoms, those of subordinate series and spark lines by multiply charged atoms. Wien and others have suggested that line spectra may be emitted by molecules, but this seems improbable. On the other hand, we must admit the possibility of negatively charged centers which would probably exist only under exceptional conditions. Nicholson has, with success, assumed the existence of positive, neutral, and negative centers in accounting for the spectrum of the corona.

The fundamental importance of reaching definite conclusions as to the magnitude of the electric charge of emission centers is evident when we remember that any theory must take this into account. Bohr's theory rests upon the assumption that series lines are emitted by electrons previously detached as they return to equilibrium positions determined by the resultant charge of the system. In the case of hydrogen, if there be but one detachable electron, the radiating system must be neutral. If it can be shown without question that the emission centers of the Balmer series are positively charged, some modification of the theory seems necessary. Furthermore, if the centers are thus deprived of the one detachable electron, we must accept Stark's view that the series emission is due to electrons which can not be detached. Fulcher has pointed out the necessity for a similar conclusion with respect to helium. Some of its lines are attributed to doubly charged atoms; but these are identical with alpha particles, the nuclei of the atoms, from which the radiation must be emitted.

Beyond the probable fact that band spectra are usually emitted by neutral systems, there is little evidence upon which we may rest a theory. Emission may accompany the neutralization of a positively charged molecule by an electron or may be the result of internal vibrations due to collisions, without complete ionization. Stark believes that the band emission is due to the detachable valency electrons, although the coupling between them and more firmly bound electrons may cause the latter to take part.

Evidence supporting Stark's views is to be found in absorption spectra. Hydrogen shows no absorption until it is ionized by a current. The cold vapors of the alkali metals and of mercury show line absorption, but their susceptibility to the photoelectric effect indicates how ionization may be the prelude to absorption. All the corresponding emission lines appear to be due to singly charged emission centers. Absorption of the lines due to multiple charges does not take place until the vapor is highly ionized by electric discharges or high temperature. Substances which show band absorption under ordinary conditions, such as iodine, do not appear to be ionized when either emitting or absorbing. Both processes appear to be due to neutral systems. In such cases emission must be due to internal disturbances, without ioniza-

tion. The bands of some substances, such as nitrogen, are not found in absorption under any conditions, and the conditions of their occurrence indicate that the emission bands are due to the recombination of a detached electron with a positive molecule. The negative pole bands appear under the same conditions as spark lines, and it seems not improbable that they are due to the neutralization of a doubly charged molecule.

The spectral differences attending different stages of ionization are well illustrated by some recent experiments. Franck and Hertz found that mercury vapor is ionized by a field of 4.9 volts, and then emits the one ultra-violet line 2537. The Einstein relation $Ve = h\nu$ is fulfilled. McLennon and Henderson verified this conclusion, and also found that with a field of about 12 volts a second stage of ionization occurs, attended by the emission of the many-lined spectrum attributed by Stark to multiple charges. McLennon finds that zinc, cadmium and magnesium also give single line spectra which probably conform with Einstein's equation, which we should not expect to apply in a simple form to the many-line spectrum.

It appears from such experiments that there is a threshold value of kinetic energy which must be imparted to an emission center before it can radiate, which represents the work of ionization and is equal to a light quantum. Franck holds that this energy may be devoted either to ionization or to emission, but that both can not simultaneously occur. Stark believes that the two are coincident, the emission accompanying the rearrangement of electrons in the atom after one has been ejected. This suggests an explanation of quantum emission involving no departure from accepted electromagnetic theory.

The spectra of hydrogen and of helium are of particular interest because their atoms are of the simplest type and because it is possible that they are the basic units of which all elements are composed. The Pickering series in stellar spectra was attributed to hydrogen because of its numerical relationships with the Balmer series. The study of series relations led Rydberg to predict the occurrence of a principal series for hydrogen beginning at wave-length 4686, and this line was subsequently found in nebular and stellar spectra. After many attempts to reproduce these spectra in the laboratory, Fowler succeeded in 1812, by passing a powerful disruptive discharge through a mixture of hydrogen and helium. Produced only under such conditions, these must be classed as spark lines; and if Stark's views are correct and if they are really due to hydrogen, that element must have more than one detachable electron.

In applying his theory to the helium spectrum, and assuming one electron returning to a helium atom from which two electrons have been detached, Bohr obtained a formula which gives lines corresponding in position to those of the Pickering and Rydberg series, and also another series almost coincident with the Balmer hydrogen series. This remarkable conclusion was strengthened by Stark's discovery of 4686 in a helium tube which gave no lines of the ordinary hydrogen spectrum. He concluded from the canal-ray displacements that the emission centers were doubly charged. Evans also found the first members of all the series assigned to helium by Bohr, including that corresponding to the Balmer series, in a tube containing no hydrogen. The experimental evidence thus favors Bohr's theory, but we must remember the remarkable way in which the presence of one element may intensify or suppress the spectrum of another. For example, Lyman found that the ultra-violet series attributed without question to

hydrogen is greatly intensified by the presence of helium. It may be added that Merton has concluded, from a study of the width of 4686, that it is due to an atom smaller than that of helium.

Some light may be thrown on this problem by observations such as those made by Wright and others on the distribution of materials in nebulæ, as indicated by the length of the nebular lines. Wright finds that usually 4686 is confined to the nucleus; helium lines extend further, and those of nebulum and hydrogen still further. These results favor the view that the elements distribute themselves according to their atomic weights and that 4686 is due to an atom at least as heavy as that of helium. But this is not conclusive, because a high temperature line of hydrogen might be found only in the hot nucleus, if we grant the possibility of a higher degree of ionization for hydrogen.

Fundamental questions which are of importance to physicists and astronomers alike are involved in this problem, but it is evidently an elusive one. Curiously enough, as Fowler has proved by comparison with other spectra, general series relations would permit us to assign the disputed series to hydrogen or to helium impartially, and it seems possible that both elements may give the same spectrum under appropriate conditions. Bohr has also concluded, from the formula derived from the assumption of the return of an electron to a lithium atom which has lost three electrons, that lithium would emit lines close to the Balmer series. Bohr has not yet succeeded in applying his method to the case where an electron returns to a singly charged helium or lithium atom, and hence has not been able to account for the known helium lines, which are assigned by Stark to singly charged atoms. Nor has he taken account of atomic magnetic fields, which, as Humphreys, Allen and others have shown, may exercise an appreciable influence.

One of the most fascinating fields of research is that of fluorescence and resonance spectra, in which much work has recently been done, particularly by Wood. He has found that white light will excite the complete band and line resonance spectrum of sodium or iodine, but that a single exciting line will cause the emission of a line of the same length and also of a number of lines approximately equally spaced which may not always coincide in position with one of the absorption lines. Thus the vapor is caused to emit forced vibration, giving a spectrum not its own. As Wood has suggested, this method enables us to strike one key of the complex vibrating system of the atom, instead of the whole keyboard at once. Time does not permit a detailed account of this remarkable work, but it is evident that it may render great service in the study of the mechanism of the atom. Nor is there time to even mention any of the results obtained in the field of absorption spectra.

After reviewing the work of the past decade, we may feel encouraged by the progress that has been made both in the perfecting and application of spectroscopic methods of research and in the discovery of new phenomena. Some of these discoveries have led to fundamental revisions of our notions of atomic structure. The Rutherford atom has definitely displaced that of Thomson. In some respects this has seemed to make the problem more difficult, but it has at least defined it more precisely. Many attempts have been made to represent an atomic structure which would satisfy the necessary mathematical conditions, most of them so impossible as to be absurd or so speculative that they suggest no experimental tests of their validity. The great merit of Bohr's hypothesis is that it does lend itself to such tests, and

it is for that reason that I have paid special attention to the methods of experimental attack which seem to give the most concrete results in this connection. Hesitant as we may be to accept in all its details a theory which asks us to abandon laws upon which we have pinned our faith, this theory, and the quantum theory as well, may be the flashes of genius which reveal incompletely the outlines of the truth toward which we struggle along a dimly lighted path. Fuller knowledge may resolve some of our difficulties and reconcile apparent contradictions. Ptolemy's theory of epicycles would appear wholly irrational to one acquainted with Newton's laws but ignorant of Kepler's conclusions, yet it correctly described the facts as Ptolemy saw them. Some day the Kepler and the Newton of the atom may appear, but their task will not be an easy one. If the astronomer is baffled by the problem of three bodies which he can see, how can we expect to define the exact laws determining the motions of the invisible hosts of electrons and positive charges in an atomic system? How can we hope to correctly picture the mechanism which emits radiations of almost infinite complexity, or account for the additional complications called forth by external forces? We may be almost tempted to accept the pessimistic view expressed by Planck in his Columbia lectures, that nothing in the world entitles us to believe that it will ever be possible to represent completely through physical formulæ the inner structure of the atom. And Kayser has said:

> A true theory must assume a complete knowledge of electrical and optical processes, and therefore is an Utopia.

But even if we never reach the goal, who can set a limit to our approach to it? We may never set foot upon the promised land, but some day we may perceive its shadowy outlines dimly from afar.

University of California E. P. Lewis

WILLIAM RANE LAZENBY

William Rane Lazenby, professor of forestry in Ohio State University, died at Columbus on September 14 of pneumonia. In the passing of Professor Lazenby there is removed from us one who has devoted his life with marked success to the advancement of agriculture and agricultural education.

He was born on a farm at Belona, Yates County, N. Y., December 5, 1850; he entered Cornell University in the fall of 1870, and graduated with his class in 1874. During this period, he not only kept up his studies, but also supported himself by labor, first, on the university farm and campus, and later, in the botanical department. This at times was an extremely difficult thing to do, as the compensation for such labor was small and the time that he could spare for this work was limited. At times he was greatly discouraged; but the steadfastness of purpose, which was a prominent characteristic of his entire career, kept him at his self-imposed task. In spite of the handicap of the necessity of self-support he was so successful in his studies that he won the Ezra Cornell prize in agriculture, and on graduation he was made a member of the teaching staff of the university.

His first appointment was as instructor in horticulture; later he was promoted to an assistant professorship in horticulture, which position he held till he was called to the Ohio State University. As he was the first member of the Cornell faculty whose duties were limited to horticulture, he may be regarded as the founder of the horticultural department of this institution.

He was called to the Ohio State University as professor of botany and horticulture in 1881, which position he held till 1892, when his title was changed to professor of horticulture and forestry; since 1910 his field has been restricted to forestry.

Professor Lazenby had published much on the subjects that he taught. He spent many of his summer vacations in studying horticulture and forestry in Europe. He was a fellow of the American Association for the Advancement of Science, a founder and past president of the Ohio Academy of Science and a life

member of the American Pomological Association and the American Forestry Society. His wife and a daughter, who is a student in Smith College, survive him.

In his undergraduate days at Cornell, Lazenby was a great favorite with his fellow students. His genial good nature, his unselfishness, and his great earnestness won the hearts of those associated with him. Already at that early period in his career, he was devotedly interested in the cause of agriculture, and took a prominent part in the work of the Grange and of agricultural and horticultural societies, and later his influence in these organizations did much to bring their support to the development of the agricultural work at Cornell. He also took a prominent part in the movement that resulted in the establishment of the agricultural experiment station at Geneva, drafting the bill, the passage of which by the New York State Legislature established this station.

While Professor Lazenby found his great interest in life the mastery and development of his special field in science, it was the human side of him that had the strongest hold on his friends and colleagues. He never lost his interest in the struggles of students with limited means and in a quiet way extended aid to many of them. He never lost an opportunity of service to his friends or others in need; sympathy, helpfulness and loyalty were his characteristic qualities as a man and friend; and his loss to all of us who knew and loved him is irreparable. J. H. COMSTOCK

SCIENTIFIC EVENTS

ANTHROPOLOGICAL ESSAYS IN HONOR OF PROFESSOR W. H. HOLMES

A FIVE-HUNDRED page volume of anthropological essays abounding with pertinent and beautiful illustrations was presented to Mr. William Henry Holmes, head curator of anthropology in the United States National Museum, on the occasion of his seventieth birthday, December 1, 1916. The volume is a tribute by his friends and colaborers in the study of anthropology, forty-four of whom contributed original articles for publication in the anniversary volume. The book, of which only 200 copies were printed, was edited by Mr. Frederick W. Hodge, ethnologist-in-charge of the Bureau of American Ethnology of the Smithsonian Institution.

The presentation took place at a dinner held at the Lafayette Hotel, at which were present most of those who took part in the preparation of the book, and proved a complete surprise to the guest of honor. Mr. Holmes has been engaged in scientific investigations under the government for forty-five years; first with the government geological surveys, then with the Geological Survey, and finally the Bureau of American Ethnology, and the United States National Museum. In fact, he has been in the scientific service of the government continuously since 1871, with the exception of three years (1894–97) during which time he was curator of anthropology in the Field Museum of Natural History and professor of anthropic geology at the University of Chicago. Besides being a geologist and anthropologist, Mr. Holmes is an artist of note, and has been curator of the National Gallery of Art, a branch of the National Museum, since its establishment several years ago. Incidentally, he has been the representative of the government at seven national and international expositions.

His influence upon the work of his collaborators and assistants has been very marked. The note of appreciation, which prefaces the anniversary volume of anthropological essays, remarks in part:

> This volume . . . must not be regarded as merely commemorative of the day on which you achieve the seventieth milestone in your journey of life. It is rather an epitome of the influence you have exerted on others through the passing years, a testimonial of your masterly leadership in both science and art. You are still at the height of your remarkable activity. At no time in your career have you done more noteworthy work in the advancement of knowledge than you are doing now. So with your splendid reserve of force, and with the inspiration derived from the important results of a generation of research in American archeology, we hope and expect you will continue to bestow upon us the influence of that experience for years to come.

Accept then, this book, not as measure of our indebtedness for what you have already accomplished, but as a token of our affection, our appreciation and high esteem.

Among the many interesting and instructive articles are thirteen written by members of the staff of the Smithsonian Institution and its branches. "The Cliff Ruins in Fewkes Canyon, Mesa Verde National Park, Colorado," is the subject of a report by Dr. Jesse Walter Fewkes of the Bureau of American Ethnology, on his recent excavation and repair of Oak-tree House, Painted House and other prehistoric ruins in the canyon. "Music in its Relation to the Religious Thought of the Teton Sioux," is the title of an article by Miss Frances Densmore. Other articles pertaining to the work of the Bureau of Ethnology are by Mr. F. W. Hodge, Miss Alice C. Fletcher, J. N. B. Hewitt, John Peabody Harrington, Francis LaFlesche, Truman Michelson and John R. Swanton.

Dr. I. M. Casanowicz, assistant curator of old-world archeology of the National Museum, writes on "Parallels in the Cosmogonies of the Old World and the New." Three other members of the museum staff contributed articles as follows: Dr. Walter Hough, "Experimental Work in American Anthropology and Ethnology," in which he speaks of the work, methods and influence of Mr. Holmes among American scientists; Dr. Aleš Hrdlička, "Anthropology of the Chippewa," wherein he reports on his studies of the White Earth Chippewa in an endeavor to establish their identity as full or mixed bloods; and Neil M. Judd, "The Use of Adobe in Prehistoric Dwellings of the Southwest."

Contributions from other eminent anthropologists include discussions on "The Cult of the Ax," by George Grant MacCurdy; "The Supplementary Series in Maya Inscriptions," by Sylvanus G. Morley; "The Domain of the Aztecs and Their Relation to the Prehistoric Cultures of Mexico," by Alfred M. Tozzer; "Cardan's Suspension in China," by Berthold Laufer, and articles by Gerald Fowke, Edgar L. Hewett, George G. Heye, Charles Peabody, Charles C. Willoughby, A. V. Kidder, S. A. Barrett, Franz Boas, Theodoor de Booy, David I. Bushnell, Jr., William Churchill, Roland B. Dixon, William Curtis Farabee, P. E. Goddard, George Byron Gordon, Albert Ernest Jenks, A. L. Kroeber, Robert H. Lowie, Charles W. Mead, William C. Mills, Warren K. Moorehead, Nels C. Nelson, George H. Pepper, Marshall H. Saville, Frank G. Speck, Herbert J. Spinden and Clark Wissler.

The volume closes with a bibliography of Mr. Holmes comprising 184 titles, which was compiled by the librarian of the Bureau of American Ethnology.

DEDICATION OF A TABLET IN HONOR OF PROFESSOR VOLNEY M. SPALDING

Several years ago at a meeting of the American Association for the Advancement of Science at Baltimore, a number of former students of Professor Volney M. Spalding got together and proposed that a fund be collected for the purchase of a memorial to their teacher. They selected a committee composed of Dr. Erwin F. Smith, of the Bureau of Plant Industry, Professor L. R. Jones, of Wisconsin University, and Professor F. C. Newcombe, of Michigan University, to select and secure the memorial.

The committee decided a bronze tablet the most suitable object for the purpose, and addressed a circular letter to Professor Spalding's former students, asking that the contribution from each be small so as to allow many to participate. Over one hundred sent in contributions, and the tablet was designed and cast. The authorities at Ann Arbor decided that the tablet should be erected in the proposed new botanical building. With the completion of the natural science building last year, the tablet was placed on the wall in the main corridor of the botanical section of the building, and dedicatory exercises held. President Hutchins presided, addresses were made by Professors J. E. Reighard and E. C. Goddard, Professor F. C. Newcombe presented the tablet in behalf of the former students of Professor Spalding, and Regent Beal accepted the tablet in behalf of the university. The inscription reads:

VOLNEY MORGAN SPALDING

In commemoration of the twenty-eight years of faithful service as teacher of botany in this university (1876 to 1904) and as a token of love and gratitude this tablet is erected by 100 of his former students.

Per naturae opera mentem ad humanitatem fingebat atque virtutem. Done in MCMIX.

It may not be known to some of Professor Spalding's pupils and friends that, since resigning from the staff of the Carnegie Desert Laboratory at Tucson seven years ago, Professor Spalding with his wife has resided the most of the time at the sanatorium at Loma Linda, Calif., where, though considerably crippled by rheumatism, he enjoys a measure of health and happiness, and is held in the highest regard by both patients and staff, with whose ills he sympathizes and to whose mental enjoyment he daily contributes.

SMITHSONIAN REGENTS MEETING

THE Board of Regents of the Smithsonian Institution assembled at the institution on December 14, 1916, for their 71st annual meeting, Chief Justice Edward D. White, chancellor, presiding. The others present were: Vice-President Thomas R. Marshall; Senators Henry Cabot Lodge, of Massachusetts, and Henry F. Hollis, of New Hampshire; Representatives Ernest W. Roberts, of Massachusetts, and James T. Lloyd, of Missouri; Dr. Alexander Graham Bell, and Mr. John B. Henderson, Jr., of Washington, D. C., and Mr. Charles F. Choate, Jr., of Boston.

Dr. Charles D. Walcott, secretary of the institution and the administrative representative of the board, announced the re-appointment by the Speaker of the House of Representatives, of Scott Ferris and Ernest W. Roberts, and the appointment of James T. Lloyd, of Missouri, to succeed Maurice Connolly, of Iowa, whose term in Congress had expired. Announcement was also made of the re-appointment of Dr. Alexander Graham Bell, of the City of Washington, as "citizen" regent, by a joint resolution of Congress. Dr. Bell was also re-elected a member of the executive committee.

The resignation of Dr. Andrew D. White, of Ithaca, New York, was presented and accepted. A resolution was adopted by the board in appreciation of his long and valued service, of nearly thirty years.

The report of the executive committee of the board was presented for the fiscal year ending June 30, 1916, and accepted. The report showed the total resources of the institution to be $1,048,134.38, and the total income for the past year to be $107,662.46. A summary of the appropriations for the several governmental branches of the institution for the fiscal year was also made.

The secretary's report for the fiscal year was presented and accepted by the board, following which he reviewed the recent work carried on and outlined the principal operations now under way. He stated that in September work was begun on the foundation of the million-dollar building donated by Charles Freer, for his collections of American and Oriental art presented to the institution some time ago, and that present indications point to its completion within two years.

A bequest by the late artist, Henry W. Ranger, gives the National Gallery of Art an opportunity of selecting and purchasing such paintings of deceased American artists as may be deemed desirable, the selected paintings being paid for from the Ranger fund.

Mention was made of the need of more funds for the proper classification and public installation of the National Museum's art-industrial collections, believed to be the richest and most varied of their kind in the country. Extensive and valuable additions to the several collections of the museum were reported as having been acquired during the year.

Among the researches of the Bureau of Ethnology, the secretary mentioned the excavation and repair of a large pueblo ruin in Mesa Verde National Park, conducted in cooperation with the Department of the Interior; and field investigations among the Fox, Quilente, Iroquois and Cherokee Indians.

In the report concerning the National Zoological Park, the need of certain tracts of land for entrances and boundaries was reported,

and the statement made, that an item for the sum required had been included in the park estimates for the fiscal year of 1918. The appointment of Ned Hollister, assistant curator of mammals of the National Museum, as superintendent was also announced. In cooperation with two other zoological institutions, the park sent a representative to South Africa to collect and purchase live animals. Recent advices from him seem to indicate excellent results.

The secretary reported briefly on the work of the astrophysical observatory on Mount Wilson, in connection with the investigations concerning the variations of the sun. An allotment has been made to Director Charles G. Abbott for the maintenance of an astrophysical observatory in South America for the purpose of determining the transmission of the sun's rays through the atmosphere.

Dr. Walcott, as chairman of the executive committee of the National Advisory Committee for Aeronautics, which organization has taken up much of the work that the Langley Aerodynamical Laboratory aimed to perform, reported considerable progress. An allotment from the Langley Laboratory, in connection with the Weather Bureau, provides for the investigation of problems of the atmosphere in relation to aeronautics, which investigation, it is expected, will ultimately result in the mapping of the atmosphere over the whole United States and adjoining areas, to a height of 20,000 feet.

Other reports concerning the operations of the Research Corporation, which handles, among other things, the Cottrell patents for the precipitation of dust, etc., the researches of Dr. Cottrell in fog precipitation and the work of Dr. C. Hart Merriam in zoology under the Harriman fund.

Among the expeditions and field work conducted recently, the secretary spoke of his own geological investigations in Alberta and British Columbia, the work of Dr. W. L. Abbott, whose gifts of ethnological and zoological specimens and generous financial contribution have been most valuable; and the zoological expedition being maintained in north China, through the generosity of another friend of the institution.

The secretary stated that the Collins-Garner Congo Expedition, in the interests of the Smithsonian Institution, was about to leave for the French Congo, where zoological collections would be secured for the National Museum, the institution and museum being represented by Mr. Charles R. W. Aschemeier.

Arrangements for a three years' lease of the Cinchona Botanical Station by the institution from the government of Jamaica, were reported as practically completed. The main building, known as "Bellevue House," situated on the Island of Jamaica, together with the offices, laboratories and other buildings and about ten acres of land, are leased by the institution for the furtherance of the study of botany in this region. Assignments to botanists desiring to prosecute studies there, will be made by a committee composed of representatives of the 14 organizations which contributed the funds for the lease.

Mention also was made of the work of the other two government bureaus under the Smithsonian; the International Catalogue of Scientific Literature, and the International Exchange Service.

Following adjournment, the regents inspected an interesting exhibit illustrating some of the many lines of work in which the institution or its branches took part during the past year.

SCIENTIFIC NOTES AND NEWS

The meeting of the American Association for the Advancement of Science and of the National Scientific Societies affiliated with it, opened in New York City on December 26 with a very large attendance. The address of the retiring president, Professor W. W. Campbell, of the Lick Observatory, on "The Nebulæ," given on the evening of the first day, will, owing to the extensive illustrations, be printed in *The Scientific Monthly*. We hope, however, to give an abstract in Science. There is printed elsewhere the address of Professor E. P. Lewis, chairman of the Section of Physics, and this will be followed by other addresses

given by chairmen of the sections and of the presidents of the affiliated societies. There will also be printed in SCIENCE the transactions of the association and reports of the proceedings of the different societies, as well as many of the more important papers presented before them.

THE number of papers announced in advance to be read before the New York meeting of the American Association for the Advancement of Science and affiliated societies listed under the related sections of the association is:

A—Mathematics and Astronomy	57
B—Physics	38
C—Chemistry	18
D—Engineering	50
E—Geology and Geography	51
F—Zoology	217
G—Botany	292
H—Anthropology and Psychology	137
I—Social and Economic Science	49
K—Physiology and Medicine	355
L—Education	53
M—Agriculture	15
Total	1,332

PROFESSOR M. I. PUPIN, of Columbia University, has been elected president of the New York Academy of Sciences, which in 1917 will celebrate its hundredth anniversary.

DR. SIMON FLEXNER, director of the Laboratories of the Rockefeller Institute for Medical Research, has been elected foreign associate member of the Paris Academy of Medicine.

PROFESSORS PAUL PAINLEVÉ, of Paris, and Vito Volterra, of Rome, have been elected honorary members of the Royal Institution, London.

DR. ROBERT A. MILLIKAN, professor of physics in the University of Chicago, will hereafter spend three months of each year in research work and lecturing at the Throop College of Technology, at Pasadena, California. This arrangement is similar to that with Dr. A. A. Noyes, professor of physical chemistry at the Massachusetts Institute of Technology, and is made possible by the recently announced gift of $100,000 for physical research.

AT a recent meeting of the corporation of Yale University, a "Yale Research Committee" was appointed to cooperate with the National Research Council. The committee is composed of President Arthur Twining Hadley; Mr. Harry Goodyear Day, of New Haven, and Mr. John Villiers Farwell, of Chicago, representing the corporation of the university; Mr. Edwin Musser Herr, of Pittsburgh, and Mr. William Wallace Nichols, of New York City, representing the alumni; and Professors Treat Baldwin Johnson, Ernest William Brown, James Farley McClelland, Ernest Fox Nichols, Charles-Edward Amory Winslow and Russell Henry Chittenden, chairman, representing the faculties.

AT its last meeting the Rumford Committee of the American Academy of Arts and Sciences made the following appropriations. To Mr. Everett T. King, of Cambridge, $25 in aid of his researches on physical measurements of the color of pigments. To Professor Edward Kremers, of the University of Wisconsin, $300 in aid of his research on the chemical action of light on organic compounds.

DR. H. S. GRINDLEY, professor of animal husbandry in the University of Illinois, was elected president of the American Society of Animal Production at the annual meeting held at the University of Illinois on December 1. Professor John M. Ervard, professor of animal husbandry at Iowa State University, was elected vice-president.

ADMIRAL SIR HENRY JACKSON, K.C.B., F.R.S., first sea lord of the British admiralty, has been appointed to the vacant post of president of the Royal Naval College, Greenwich, and has been succeeded as first sea lord by Admiral Sir John Jellicoe, K.C.B.

Nature states that Dr. Eric Mjöberg, assistant in the entomological department of the Swedish State Museum, has received leave of absence for three years in order to prepare and conduct an expedition to the interior of New Guinea. His intention is to penetrate into the country by aeroplane, taking as his starting point one of the small islands in Geelwink Bay, at the northwest end of the country. Dr.

Mjöberg recently left for America to carry out a lecture tour by which he hopes to raise sums to cover some of the expenses of his expedition.

Major-General George W. Goethals will speak in the Great Hall of the College of the City of New York on the evening of January 15, on "The Panama Canal." General Goethals was formerly a student of the City College.

Professor Robert A. Millikan, of the University of Chicago, will deliver the William Brewster Clark Memorial lectures at Amherst, probably early in January. The subjects of his four lectures will be: "The Nature of Electricity"; "Brownian Movements and the Kinetic Theory"; "The Insides of the Atom"; "The Nature of Radiation."

Dr. E. W. Scripture recently read to the Pathological Section of the Royal Society of Medicine a communication on registration of speech sounds in the diagnosis of nervous diseases.

Mr. F. W. Lanchester, the new president of the Junior Institution of Engineers, will deliver his inaugural address to the institution on Monday, December 11, on "Industrial Engineering: Present Position and Post-War Outlook."

According to the *Journal* of the American Medical Association the late Professor A. Neisser, the distinguished pathologist, bequeathed his property to the city of Breslau. It is valued at nearly $400,000. He stipulated that his villa with its art treasures be maintained as a museum for contemporaneous art, and further, that the rooms be used in giving high-grade municipal concerts and similar entertainments.

Professor J. Wrightson, president of the College of Agriculture, Downton (1880–1906), honorary professor of agriculture at the Royal Agricultural College, Cirencester, and professor of agriculture and agricultural chemistry in the Royal College of Science, South Kensington, from 1882 to 1898, died on November 30.

The committee which was formed with the object of commemorating the late Sir William White's services to the nation in the development of engineering science, and more particularly of naval architecture, has now completed its task. A sum of over $15,000 was raised by private subscriptions, and this amount has been expended as follows: (1) The provision of a fund for providing a Post Graduate Research Scholarship in Naval Architecture of over £100 per annum, tenable for two years; (2) the erection of a Memorial Panel; (3) a donation of one hundred guineas to the Westminster Hospital. The Memorial Panel has been erected in the entrance hall of the Institution of Civil Engineers. The Research Scholarship Fund has been made over to the Council of the Institution of Naval Architects, who will administer the fund and award the scholarship. The latter is to be known as the "Sir William White Research Scholarship in Naval Architecture."

The *London Times* states that Christmas Island, in the Indian Ocean, 780 sea miles from Singapore, is suffering from the war. Its sole wealth consists in phosphates of lime, and exports decreased from 150,000 tons in 1913 to 25,700 in 1915. Formerly Germany and Austria took large quantities of its phosphates; in 1915 the whole export went to Australia.

UNIVERSITY AND EDUCATIONAL NEWS

An anonymous gift of $250,000 has been added to the endowment fund of the proposed medical school of the University of Chicago. The total amount of the fund has now reached four million dollars, leaving one million three hundred thousand dollars to be collected.

Purdue University is erecting a building of brick and Bedford stone for the school of science. In floor area it will be one of the largest structures on the campus.

The number of students during the summer semester of 1916 in the Austrian universities is reported to be as follows: Vienna, 3,472; Prague (Czech University), 1,891; Cracow, 1,281; Lemberg, 1,174; Graz, 647; Prague (German University), 638; Innsbruck, 584. The proportion of medical students was highest at Vienna and at Graz (both about 30 per

cent. of the total). At Vienna nearly two fifths of the medical students are women.

THE following promotions have been made at the College of the City of New York: From instructors to be assistant professors: Philosophy, Dr. Howard D. Marsh; mathematics, Dr. Paul H. Linehan; chemistry, Dr. Robert W. Curtis and Dr. William L. Estabrooke. From assistant professorships to associate professorships: Physics, Dr. Joseph G. Coffin.

AT the Iowa State College Dr. Charles A. Mann, of the University of Wisconsin, has been appointed associate professor of chemical engineering to succeed Professor George A. Gabriel, who goes into practical work.

DISCUSSION AND CORRESPONDENCE

A REPLY TO "METHODS OF CRITICISM OF 'SOIL BACTERIA AND PHOSPHATES'"

IN the issue of SCIENCE of November 3, 1916[1] Drs. Hopkins and Whiting have taken occasion to arraign me for having sent to certain editors of agricultural papers a letter headed "Confidential and Not For Publication." They also impugn my motives in writing the letter, for they say it was evidently done to "belittle" the importance of their work, whereas my reason for doing so is explained very fully in the second paragraph of the letter, appended below, and as stated, it was sent to the editors because the work of Hopkins and Whiting was "unfortunately being used by some writers for the purpose of making it appear that the same reaction will take place in the soil in connection with raw rock phosphate to essentially the same extent."

Instead of publishing my letter in full, Drs. Hopkins and Whiting quote only certain parts because of alleged lack of "space," but space was taken, nevertheless, to enter into a lengthy discussion of the validity of the work of Professor Mooers and of Director Thorne on raw rock phosphate, and the intimation was made that I had overlooked some work of the latter. This was seemingly not germane to the real issue, for instead of my having attempted to review their work, I wrote to each of them asking what their results actually showed, and merely quoted, with permission, from their letters. In fact, these letters were of a later date than the literature cited by Hopkins and Whiting in refutation of Mooers' and Thorne's conclusions.

It will be seen, therefore, that the attack by Hopkins and Whiting on these statements resolves itself into an allegation that Professor Mooers and Director Thorne were, in their opinion, incompetent to analyze their own work properly or had misrepresented it to me. This fact I regret exceedingly, for no agricultural investigators in the United States are held in higher esteem by their colleagues than Mooers and Thorne, and hence such allegations can only result in injury to those who make them.

Had my letter been intended as an unfavorable criticism of the work of Hopkins and Whiting, they would most assuredly have been favored with a copy immediately. It was, however, only intended, as stated in the letter itself, as a criticism of the improper use that other persons were making of their results.

I take pleasure in introducing below my letter of July 28, 1916. The reader is asked to note carefully if the letter constitutes an unfavorable criticism of the work of Drs. Hopkins and Whiting or if, as intended, it is merely an appropriate warning to the agricultural press not to draw too far-reaching and improper conclusions from it, for this is the real point at issue.

BOSTON, MASS., July 28, 1916

Confidential and Not For Publication

Dear Sir: My attention has been called within a few days to several articles appearing in the agricultural press which have been inspired by Bulletin No. 190 of the Illinois Agricultural Experiment Station. It appears that Drs. Hopkins and Whiting have experimented with the microorganisms which produce nitrous and nitric acid by the oxidation of ammonia. The work was done in water cultures into which artificially prepared and purified tricalcium phosphate had been introduced. They claim to have shown that the nitrite bacteria caused the lime and phosphoric acid of a highly insoluble phosphate to become soluble.

While this work is of much value as a scientific contribution, it is unfortunately being used by

[1] Vol. XLIV., No. 1140, p. 649.

some writers for the purpose of making it appear that the same reaction will take place in the soil in connection with raw rock phosphate to essentially the same extent. This, however, is not true, as will be explained.

All agricultural soils contain the bases soda, lime, potash and magnesia combined as silicates. Often these silicates are highly basic or, in other words, the proportion of base to the silica is so great that pure water will dissolve appreciable quantities of the bases. Furthermore, if soils have been limed heavily, especially with coarse limestone such as has been recommended by Dr. Hopkins, they are likely to contain in addition some carbonate of lime. The organic acids and the carbonic acid produced in the decomposition of vegetable matter or brought down in the rainfall, including also nitrous and nitric acid, produced as described above, tend to unite in the soil with the most readily attackable bases in the basic silicates and with the lime of the carbonate of lime before they can attack raw rock phosphate effectively. In other words, when nitrous acid is produced in a soil which has been properly limed and has, therefore, been rendered sufficiently basic for the best production of agricultural plants, it is incredible that all or most of it will react upon raw rock phosphate in the soil to the extent that it did in the water cultures used by Hopkins and Whiting in which there was nothing but phosphate which it could attack.

In this connection let me cite Lyon, Fippin and Buckman who, in their recent book on soils, say:

"It has been found, for instance, that calcium carbonate decreases the availability of raw rock phosphate and bone meal."

This action of the calcium carbonate is similar to the action of the highly basic silicates, and it corresponds to the action of the ammonia in stall manure when it is stored under the best conditions for its preservation, for the ammonia combines with the acid so readily as to interfere seriously with its solvent action on raw rock phosphate. In fact, it was probably because of this that Hartwell and Pember in Rhode Island and Hart and his coworkers in Wisconsin failed to demonstrate that composting manure and raw rock phosphate made the latter soluble or highly available to plants.

In this connection note what Director Thorne, of the Ohio Agricultural Experiment Station, says:

"Where we have used floats as a reenforcement of manure on this farm alongside of acid phosphate, the acid phosphate has given us a slightly larger net gain in the average of the 18 years' work, and a decidedly larger gain during the last half of this period—a result the opposite of what we expected when we started the experiment. The floats and the acid phosphate being used in the same quantity, or 40 pounds per ton of manure, we expected that the larger accumulation of phosphorus in the soil due to the floats would finally result in the floats exceeding the acid phosphates in total and net gain, but this has not happened."

If there were such a tremendous solvent effect of raw rock phosphate in the soil as some writers would make us believe after they have read and commented upon this bulletin, it is surprising that the Tennessee Agricultural Experiment Station should report as it does on raw rock phosphate, for Professor Mooers says:

"In reply to your recent inquiry will say that we have not published anything recently with regard to the comparative values of acid phosphate and rock phosphate, but we have conducted experiments with these two materials on various types of soil in different parts of the state for the past ten years. The results of our experimental work do not allow us to recommend raw rock phosphate for general use. In fact, we discourage its use anywhere in the state and recommend acid phosphate as the most profitable of all phosphates. In some of our experimental work the raw rock has given profitable returns, but in no instance clearly equal to acid phosphate. In all of the experiments the two materials have been used in approximately equal money values and in connection with green manuring, which is supposed by some to increase appreciably the availability of rock phosphate.

"In some of our experiments conducted on soils especially poor in phosphoric acid the returns from the rock phosphate have been very meager and not at all comparable with those from acid phosphate. For us to give the preference to rock phosphate would be to ignore all of our experimental data. I may add that when the land is limed the acid phosphate shows considerably greater superiority over the rock phosphate than where unlimed."

The work of Hopkins and Whiting was done on an especially soluble, artificial tricalcium phosphate, in a solution in a glass vessel kept at a high temperature where the acid could attack nothing but the phosphate, whereas the farmer has to deal with a soil containing far more readily decomposable silicates and carbonates, substances upon which the acid can react to a very large extent before it has a chance to attack the less soluble raw phosphate rock.

Let us appreciate this work of Hopkins and Whiting as an interesting contribution to the study of nitrification, but let us not draw too far-reaching and improper conclusions from it which are only partially applicable to field conditions.

In fact Hopkins and Whiting say in this Bulletin that:

"The addition of limestone with the insoluble phosphates prevents the detection of soluble phosphates."

They also say that:

"The nitrous acid produced may act upon compounds of iron, aluminum, potassium, sodium or magnesium which occur in soils, or it may act upon tricalcium phosphate, calcium silicate or calcium carbonate, if present."

In their hope of confining the solvent action of the nitrous acid as fully as possible to the raw phosphate rock, Hopkins has recommended that the phosphate be turned under in intimate contact with organic matter, yet when one realizes the even closer contact of the many soil particles with the organic matter at the same time, it will be obviously impossible for the nitrous acid to attack wholly or even chiefly the raw rock phosphate. This idea is fully supported by Thorne's practical field tests in Ohio, by the work of Mooers and others in Tennessee, and by the collective evidence of practically all of the agricultural chemists in the United States and Europe.

H. J. WHEELER

I gladly leave the judgment of the ethical and scientific questions involved to the impartial court of my colleagues at home and abroad.

H. J. WHEELER

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1916 OR 1816?

THE following announcement has appeared in the *Washington Times,* Wednesday, December 20, 1916:

PHRENOLOGIST TO SPEAK

Professor G. W. Savory, a graduate of the Fowler School of Phrenology of New York, will address the Enosinian Literary Society of George Washington University on the evening of January 15. His subject will be "Brains—How to Know and Handle Them." The lecture will be given in the assembly hall of the Arts and Sciences Department building, 2023 G street northwest.

Comments would seem superfluous.

A. HRDLIČKA

QUOTATIONS

SCIENCE IN GERMANY FROM AN ENGLISH VIEWPOINT

GERMANY has been held up to us so long as the model in all matters of state organization that most English students of institutions will read with surprise the letter published in another column, which has been addressed by the Committee of the Institution of German Engineers to Herr von Bethmann Hollweg in favor of the opening of the German civil service to men of scientific training. To-day the higher branches of the German civil service are reserved for lawyers, and are not open to graduates of the technical high schools. The evil of this system has long been felt in Germany. Ten years ago the German government admitted that the higher branches of their civil service were not manned in accordance with the requirements of the time. The training of those officials, even since the reforms of 1906, consist of a secondary-school course with a strong bias towards the humanities, followed by a short university course almost exclusively composed of legal subjects. The ordinary law course is the higher civil service course. Whatever a student's inclination or tendency may be, the legal training is a condition precedent to a civil service career. "Civil servants," the chancellor is told with pathetic force, "are called upon to deal with problems the expert solution of which calls for just the type of mental equipment that is provided by the technical high schools. . . . The forcible exclusion of the intellect that is available amongst these circles from participation in the higher civil service constitutes a waste of the intellectual powers of our nation."

The loss of the German nation under such an absurd system is not our concern; the point that we are interested in is that this nation, which claims to lead the world in administrative efficiency is in this instance, at least as dissatisfied with its achievements in the most important part of the organization of a nation as even England herself. Of course all the world knows now that Germany has long eked out her various weaknesses in administration by trumpetings that have brought down with a run the Jericho walls of foreign

prejudice. She has so long and so loudly insisted that she leads the world in all organization and administration that it is a shock to find that her civil service is admittedly inefficient. It is already well known that her social science, as reflected in the infant death-rate, is inefficient. Various branches of her educational system are very weak and ill-organized. We are beginning at last to realize that German face-values are not always true values. But this, though entertaining, is not necessarily comforting to us. Is our own Home Civil Service, devoted though it is, selected on a system that is calculated to secure men who have, as part of their outfit, the scientific method of thought? We do not want pure or applied scientists for our service any more than the Germans want lawyers. We believe that the German engineers are wrong in the system that they would substitute for the legal system. What is needed for an efficient civil service is a class of men and women trained to think, to see and to foresee.—*London Times Educational Supplement.*

SCIENTIFIC BOOKS

Soils, Their Properties and Management. By T. Lyttleton Lyon, Ph.D., Professor of Soil Technology; Elmer O. Fippin, B.S.A., Extension Professor of Soil Technology; and Harry O. Buckman, Ph.D., Assistant Professor of Soil Technology, all of Cornell University. New York, The Macmillan Company. 764 pages.

This is a very complete text on soil technology, as can be seen from the following chapter heads: I. Some General Considerations; II. Soil-Forming Processes; III. The Geological Classification of Soils; IV. Geological Classification of Soils (Continued); V. Climatic and Geochemical Relationships of Soils; VI. The Soil Particle; VII. Some Physical Properties of the Soil; VIII. The Organic Matter of the Soil; IX. The Colloidal Matter of Soils; X. Soil Structure; XI. The Forms of Soil Water and their Movement; XII. The Water of the Soil in its Relation to Plants; XIII. The Control of Soil Moisture; XIV. Soil Heat; XV. Availability of Plant Nutrients as Determined by Chemical Analysis; XVI. The Absorptive Properties of Soils; XVII. Acid or Sour Soils; XVIII. Alkali Salts; XIX. Absorption of Nutritive Salts by Agricultural Plants; XX. Organisms in the Soil; XXI. The Nitrogen Cycle; XXII. The Soil Air; XXIII. Commercial Fertilizers; XXIV. Soil Amendments; XXV. Fertilizer Practise; XXVI. Farm Manures; XXVII. Green Manures; XXVIII. Land Drainage; XXIX. Tillage; XXX. Irrigation and Dry Farming; XXXI. The Soil Survey.

Particular attention should be drawn to the all too brief chapters on the organic matter and the colloidal matter of soils, both of which are admirably done. The discussion is clear and to the point. Too often organic matter is hazily treated, and colloids neglected entirely. As a book of reference for students of soils this text is exceptionally good, not only for the subject-matter itself, but also for the profuse bibliography. But as a text for a general class in soil technology it is somewhat too comprehensive, and the subject-matter not sufficiently coordinated. The various phases of soil study are taken up as separate subjects and not treated as parts of a whole. Although the soil is a very complex material, its various functions work together and should be studied in their interrelationships.

There are a few corrections to be made. The word "protein" is better than "proteid," page 12, line 7. The formula for kaolinite on page 22 does not agree with the formula on page 9. The latter is correct. On page 128, line 14, "proteosis" should be "proteoses." There is too frequent use of the phrase "and the like" after a series of names. It is as bad as too many "and so forths."

The typography and binding are excellent. Such illustrations as are given are good, but a text should be more profusely illustrated for the average student. Good pictures well chosen add very greatly to the pedagogic value of a text-book. All things considered, however, the authors are to be congratulated on producing a book so complete, so accurate, so well written, and so useful to all students of the soil.

C. W. Stoddart
State College, Pa.

Organic Agricultural Chemistry (*The Chemistry of Plants and Animals*). A text-book of general agricultural chemistry or elementary bio-chemistry for use in colleges. By JOSEPH SCUDDER CHAMBERLAIN, Ph.D., Professor of Organic and Agricultural Chemistry in the Massachusetts Agricultural College. New York, The Macmillan Company, 1916. 319 pages.

In following out certain modern ideas that science can be applied from the beginning and not lose any of its scientific value, this text comes as a distinct change from the usual books on the subject of organic and agricultural chemistry. It starts in with a brief description of systematic organic chemistry, but keeps in mind all the time that the compounds described have an agricultural value. Then follows a section on physiological chemistry dealing first with animals and then with plants. Finally there is a section on crops, foods and feeding which presents "the chemical basis for the valuation of animal foods but without entering into the discussion of the practical operation and results of animal feeding."

The following are the chapter headings: Section I. *Systematic.* Chapter I. Hydrocarbons; II. Substitution Products of the Hydrocarbons; III. Oxidation Products of Alcohols; IV. Derivatives of Alcohols and Acids; V. Mixed Compounds; VI. Amino-Acids, Proteins, Urea, Uric Acid; VII. Carbohydrates. Section II. *Physiological.* Chapter VIII. Enzymes and Enzymatic Action; IX. Composition of Plants and Animals; X. The Living Cell and Its Food; XI. Animal Food and Nutrition; Digestion and Absorption; XII. Animal Food and Nutrition; Metabolism; XIII. Milk, Blood and Urine; XIV. Plant Physiology. Section III. *Crops, Foods and Feeding.* Chapter XV. Occurrence and Uses of Important Constituents in Agricultural Plants; XVI. Occurrence and Uses of Important Constituents in Agricultural Plants (Continued); XVII. Animal Foods and Feeding.

One criticism to be made is of the statement occurring now and then that certain processes can not be explained here, or that it is unnecessary to give the proof for some reaction. In an elementary text it is not wise to make such statements. It is far better to give as many of the facts as are desirable or necessary for the case in point and make no apologies. Another fault to be found is that there are no illustrations. All texts should be generously illustrated with good pictures if the average student is to make the best use of the book.

The idea of using only those compounds occurring in a study of agricultural chemistry is well worked out, and the student is carried rapidly from simple to complex forms without any loss of time and without any loss of the unity or coordination of systematic organic chemistry. This section shows very well how such a subject can be practically applied without losing any of the pure science. In the section on physiological chemistry the action of enzymes and the chemistry of the cell are made very plain. Crops are discussed briefly but efficiently, and the question of nutrition treated with just enough detail to acquaint the student with the underlying principles.

The book is well printed and neatly bound. It is a volume to be recommended to those who desire a condensed treatment of biochemistry, being thoroughly scientific and yet practical and interesting.

C. W. STODDART

STATE COLLEGE, PA.

THE UNITED STATES GEOLOGICAL SURVEY MAPS

THE thirty-seventh annual report of the U. S. Geological Survey states that the project of covering the 3,000,000 square miles of the United States with accurate topographic surveys was definitely adopted by the federal government in 1882, and the work is even now less than half completed. The standards of accuracy and refinement in topographic surveying have been constantly raised by the topographic engineers, with the view of meeting adequately every use to which the resulting maps can be put. The law provides for the sale of the United States Geological Survey maps at the

cost of printing, a charge that must be considered merely nominal when it is realized that the cost of an edition of the printed map may be only a small percentage of the cost of surveying the area it represents. The government itself is making a large and increasing use of these topographic maps, but the expenditure of public funds for these surveys is otherwise fully warranted only as the public uses the maps. To promote this use, the survey has recently given more attention to the wider distribution of the maps.

The distribution of a government map is largely a problem of publicity, though the necessity of adopting commercial business methods in handling orders for the maps when once a demand is created must not be overlooked. In informing the public of the existence of authoritative maps published by the federal government a special effort is now made to reach the communities in each area covered by a map, and to this end every map as issued is brought to the attention of the local and state press, as well as of postmasters and school-teachers.

Other methods of promoting wider distribution involve the cooperation of boy-scout masters, schoolboys and hotel managers, as well as of a large number of bookstores as local agents.

Within the last year the most helpful publicity has been gained through the voluntary cooperation of several press services and magazines of large circulation, in connection with their policy of bringing the people into closer touch with the work and publications of the federal government. The publication in one magazine of a brief statement regarding the Geological Survey's maps resulted within a month in orders for 550 maps and thousands of inquiries for the state indexes that show the areas already mapped.

The periods of maximum demand for these governments maps are the beginning of the vacation period and the beginning of the school year. The larger use of topographic maps in 1915–16, both in the open and in the classroom, is a gratifying index of the popular benefit already resulting from the increase in the work of publicity.

A NEW INSECT ENEMY OF THE PEACH

An insect destructive to the peach and kindred fruits, believed to be new in the United States, has been discovered by entomologists of the U. S. Department of Agriculture in the District of Columbia and its environs. This insect, which in its adult form is a brownish moth and in its larval stage a small white and pink caterpillar, attacks both the tender shoots and fruit, causing serious losses.

Because of the habits of the worm, the usual control measures, such as spraying with certain arsenates, will probably not be effective. The smooth young shoots, owing to their rapid growth, are protected by the poison solution for only a very short time after the spray is applied, and hence it is almost impossible to poison them. The entomologists of the department who have been investigating the pest, will continue to study it in the hope of developing control measures.

The insect, known to science as *Laspeyresia molesta,* is believed to have been introduced from Japan. So far as the department's entomologists know, it has not been found in America other than in the District of Columbia and in the adjoining territory in Maryland and Virginia. The specialists are desirous of knowing if the insect has attacked peach, plum or cherry trees elsewhere in the United States.

The presence of the insect can best be determined in most cases by the nature of its injury to peach trees. It bores into practically every tender twig and causes new shoots to push out from lateral buds. These are attacked in turn, the abnormal stimulation of lateral growth producing a much branched and bushy plant. A copious flow of gum from the twig-ends often follows the attacks of the caterpillars.

In attacking fruit the young caterpillars generally eat through the skin at or near the point of attachment of the fruit stem. The larva, as it grows, makes its way to the pit, where it feeds on the flesh, which soon becomes much discolored and more or less slimy. Larvæ entering at the side of the fruit are more likely to eat out pockets or cavities in the flesh. The full-grown caterpillar spins a whit-

ish silk cocoon in which to pupate. Moths emerge in the spring for egg-laying by the time the shoots are well out.

The Bureau of Entomology, U. S. Department of Agriculture, especially requests owners of peach or other fruit trees to report the presence of this new pest in their orchards. Specimens of twigs may be mailed wrapped in paper or, preferably, in a suitable box.

SPECIAL ARTICLES

THE HABIT OF LEAF-OVIPOSITION AMONG THE PARASITIC HYMENOPTERA

ENTOMOLOGISTS have for several years been more or less familiar with the strange habit of leaf-oviposition among the parasitic Diptera. Up to the present time, however, no such startling deviation from the normal has been observed in parasitic Hymenoptera.

A few years ago the writer, while engaged in the study of the hymenopterous parasites of the gipsy moth for the United States Bureau of Entomology, carried on an investigation of the life-history and habits of *Perilampus hyalinus,* a hyperparasite of the fall webworm. The first stage larva, a very curious being heavily armored with chitinous plates and provided with numerous hooks and curved spines, was found crawling about on the outside of the caterpillar. Later these first-stage larvæ or planidia were found to bore their way into the body cavity of the caterpillar, there swimming about freely until the primary parasite larva, either hymenopterous or dipterous, was found and into which they gained entrance. The *Perilampus* larva then remained quiescent until the primary parasite became full-fed and made its exit from the caterpillar to spin its cocoon or form its puparium. At the time of ecdysis the planidium found its way to the exterior of the host, after which it fed as an ectophagous parasite in the normal way. The egg-laying habit of this strange parasite has, however, remained a riddle to entomologists and has been the subject of considerable speculation. For several years the writer has been looking for a solution of this problem, but the opportunity did not present itself until about two weeks ago.

During the previous summer specimens of *Perilampus* were occasionally bred from *Chrysopa* cocoons. Recently the writer was successful in capturing several adult female *Perilampus* of this species hovering about oleanders infested with *Aphis nerii* and fed upon by *Chrysopa.* These were taken into the laboratory and placed in vials, each with an oleander leaf which bore egg-clusters of *Chrysopa.* The insects were then watched and were observed frequently to touch the tip of the abdomen to the leaf. On placing the leaf under the binocular microscope the minute transparent eggs of the *Perilampus* were seen, one end of the egg being slightly attached to the leaf. This observation established beyond doubt the habit of leaf-oviposition among the parasitic Hymenoptera. The eggs are numerous, one female depositing fifty-two in a single day. They hatch in seven to ten days and the first stage larva is of the planidium type. The planidium is active at first, crawling rapidly about, but later it attaches itself to the leaf by the caudal end, standing out at right angles to the surface, where it awaits the approach of the *Chrysopa* larva and to which it attaches itself by means of the numerous hooks with which it is provided.

It is difficult to understand just what is gained, from the standpoint of *Perilampus* infesting *Chrysopa,* by this extraordinary habit, since the *Chrysopa* larva is easily accessible to the normal method of oviposition and is in fact parasitized in the larval state by a number of parasites which oviposit directly into the host. In the case of *Perilampus hyalinus,* however, and other species having similar habits, the advantage is obvious, since by no other method could access be had to the larvæ of the primary parasites. In the case, too, of those species of *Perilampus* infesting wood-boring Coleoptera and gall-making and stem-infesting Lepidoptera (the correctness of which records the writer is frank to confess he previously looked upon with doubt), the usefulness of this method of oviposition taken with the active planidium stage is readily seen, since in this way access is easily gained to the endophagous host through the wanderings of

the planidium. Needless to say this type of reproduction forms one of the most extraordinary adaptations to environment in the entire annals of entomology.

Harry Scott Smith
California State Insectary,
Sacramento, Calif.

SOCIETIES AND ACADEMIES

NEW ORLEANS ACADEMY OF SCIENCES

On Tuesday, November 22, 1916, the academy held a special public meeting to arouse the citizens of New Orleans to the danger threatening vegetation by the presence in the city in vast quantities of the Cottony Cushion Scale. More than two hundred people were present. Mr. T. E. Holloway, of the U. S. Bureau of Entomology, read a telegram from Mr. L. O. Howard regretting his absence, and then read a paper on the life history of the scale. Mr. E. Foster, assistant state entomologist, read a paper upon the different ways in which the scale was being disseminated. Mr. E. R. Barber, of the Bureau of Entomology, read a paper upon the relation to the scale of the Argentine ant, and showed how the presence of the ant complicated the situation. Professor R. S. Cocks, professor of botany, Tulane University, called attention to the very large number of host plants, over seventy, already being attacked, and the probability that the number would be greatly increased. Mr. J. B. Garrett, state entomologist, emphasized the importance of importing from California or Florida sufficient numbers of the vidalia beetle as the only way to control the pest.

After some discussion, a committee was appointed with Mr. Clarence F. Low, chairman, to call upon the mayor and request that the city supply the requisite funds to carry on the fight.

It is gratifying to be able to relate that the city authorities were properly impressed by the committee, and, together with the state, have agreed to furnish the requisite funds for obtaining and propagating the beetles.

R. S. Cocks,
Secretary

New Orleans Academy of Sciences
December 4, 1916

THE BOTANICAL SOCIETY OF WASHINGTON

The 115th regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club at 8 P.M., Tuesday, November 7, 1916.

Michael Shapovalov, Dr. Howard G. MacMillan, Dr. Joseph Rosenbaum and F. E. Miller were elected to membership in the society.

Under Brief Notes and Reviews of Literature, Mr. W. T. Swingle called the attention of the society to a recent edition of an ancient Chinese work on botany, "The Cheng lei pen ts'ao," originally published in A.D. 1108. Dr. A. T. Tenaka reviewed briefly a recently issued "Handbook of Plant Diseases of Japan," by Jinzo Matsumura.

Dr. R. H. True presented a paper on notes on the life of John Bradbury. Information concerning the life of this early naturalist and explorer of the Missouri Valley is very meager. A considerable addition has been gained from the correspondence carried on between Bradbury and Thomas Jefferson who greatly influenced the course of Bradbury's life and work in this country. Bradbury's life, gathered from this and other available sources, was sketched in outline.

Pathological problems in the distribution of perishable plant products were discussed by Dr. C. L. Shear and Dr. W. A. Orton. The enormous losses in recent years caused by the deterioration and decay of fruits and vegetables between the field and the consumer have led to a more active interest in this subject and a desire on the part of those most directly affected to have the causes and means of prevention determined.

In most cases fungi are the active agents in causing the destruction of such products, and the problem is primarily pathological. In order to devise means of avoiding these losses, a thorough knowledge of all the factors and conditions involved must be obtained. Each fruit and vegetable has its own peculiarities and its own parasites. In some cases the cause of loss may be traced to the field, and in others to conditions of transportation and handling. In any specific case the cause and responsibility for the loss can only be determined by careful investigation of all the facts.

Specific cases of losses to strawberries, peaches, cranberries, watermelons, tomatoes and potatoes were cited to show the complexity of the problems and the danger of drawing any general conclusions from insufficient data. It was shown that the means of preventing such losses will depend upon the nature of the cause or causes, as determined by a knowledge of all the factors in any particular case.

The scientific program was followed by a social hour, with refreshments.

H. L. Shantz,
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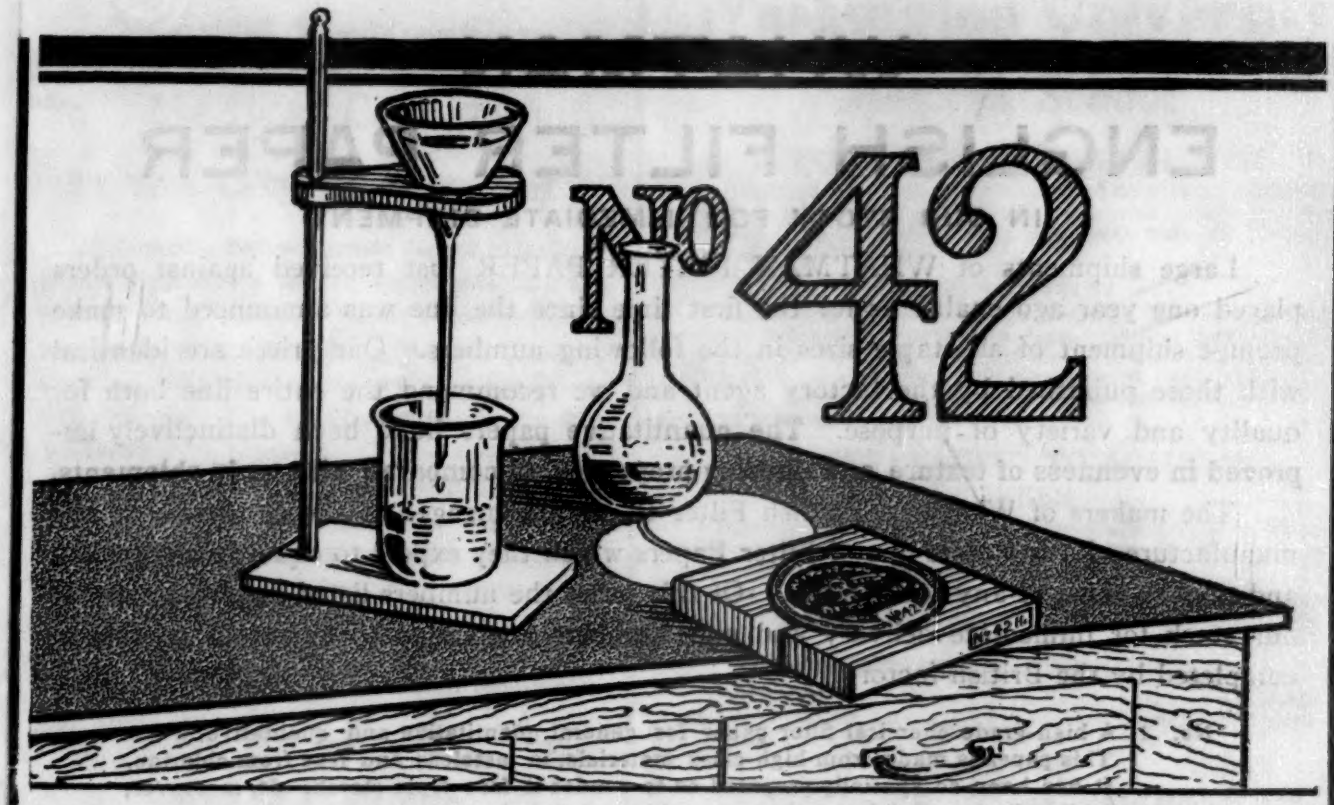

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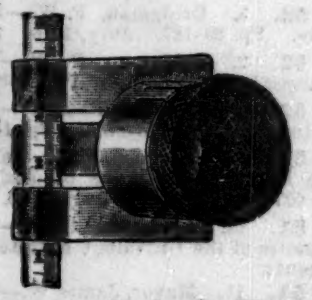

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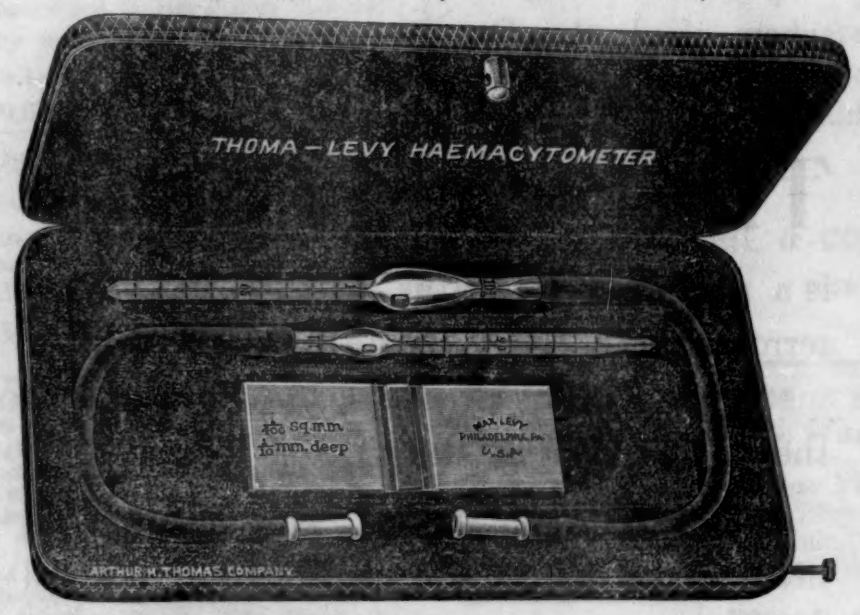

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Department B.

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Medical School

REQUIREMENTS FOR ADMISSION

Candidates for entrance are required to have completed at least two full years of college work which must include English, German, and instruction with laboratory work in Physics, Chemistry and Biology.

INSTRUCTION

Instruction begins on the last Thursday in September and ends on the second Thursday in June. Clinical instruction is given in the Barnes Hospital and the St. Louis Children's Hospital, affiliated with the medical school, the St. Louis Mullanphy Hospital, the St. Louis City Hospital, and in the dispensaries connected with these institutions.

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The annual announcement of the Medical School or the Register of the University will be sent upon application to THE DEAN of the **STANFORD UNIVERSITY MEDICAL SCHOOL, Sacramento and Webster Streets, San Francisco, California.**

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School of Medicine

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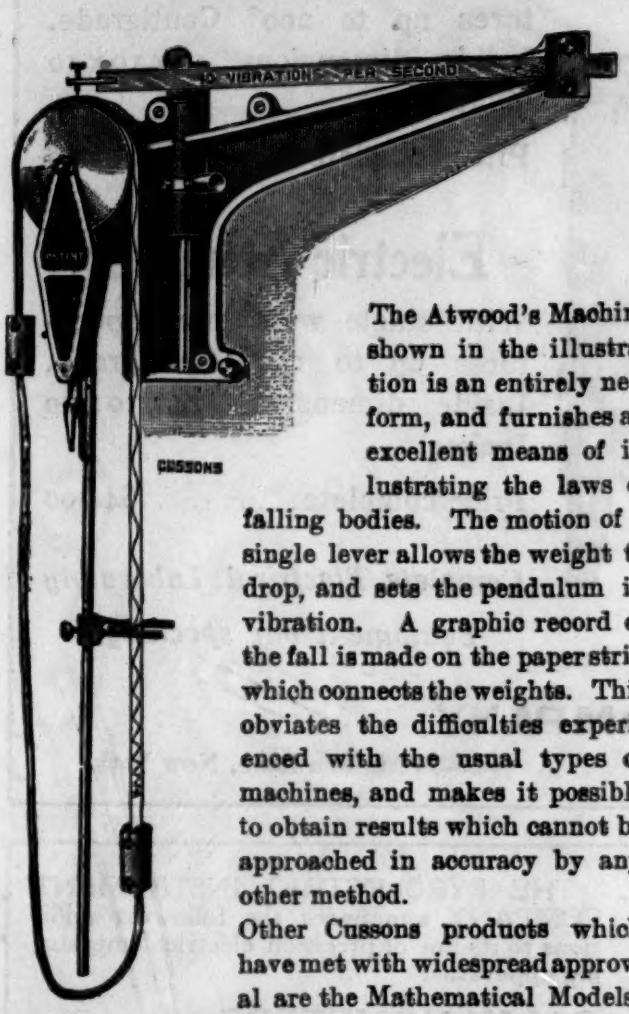

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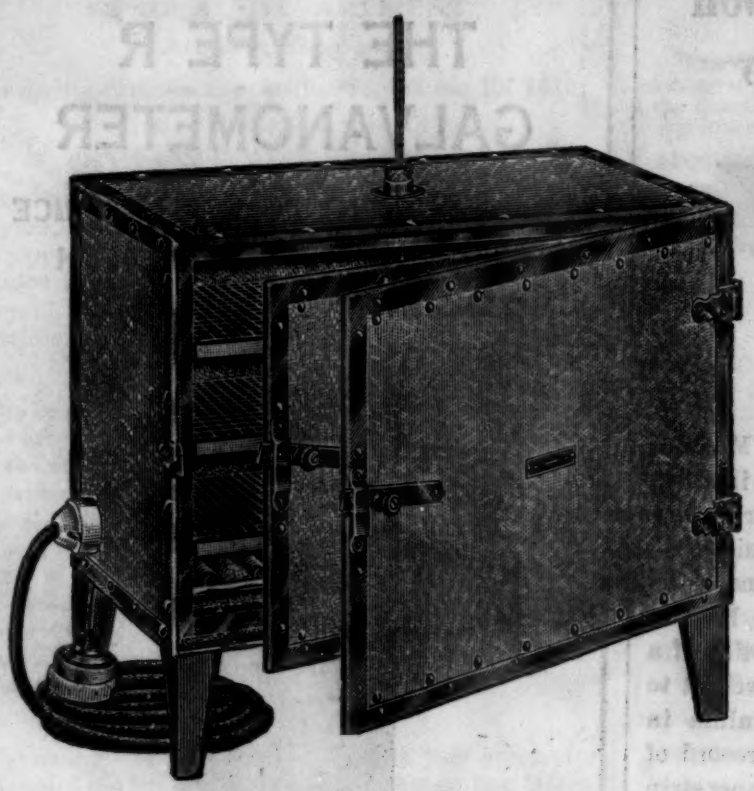

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